CLAIMS

1. An erosion resistant coating, comprising:

a metal matrix; and

a plurality of hard particles embedded in the metal matrix, wherein the plurality of hard particles are spaced apart at an average distance equal to or less than 10 microns.

2. The erosion resistant coating of Claim 1, wherein the plurality of hard particles have a film of material different from the metal matrix on or about a surface of each one of the plurality of hard particles.

3. The erosion resistant coating of Claim 1, wherein the plurality of hard particles are spaced apart at the average distance of less than about 5 microns.

4. The erosion resistant coating of Claim 1, wherein the plurality of hard particles and the metal matrix form a substantially continuous film.

5. The erosion resistant coating of Claim 1, wherein the plurality of hard particles have an average diameter of about 0.25 microns to about 12 microns.

6. The erosion resistant coating of Claim 1, wherein the metal matrix is selected from a group consisting of cobalt based alloy, a nickel based alloy, and an iron based alloy.

7. The erosion resistant coating of Claim 2, wherein the film comprises a nickel, chromium, and/or titanium compound at a thickness effective to stabilize the hard particles.

8. The erosion resistant coating of Claim 1, wherein the erosion resistant coating is formed by an electroless plating process.

9. The erosion resistant coating of Claim 1, wherein the erosion resistant coating is formed by an electroplating process.

10. The erosion resistant coating of Claim 1, further comprising an additive dispersed in the erosion resistant coating, wherein the additive is selected from the group consisting of oxides, borides, nitrides, carbides, phosphides, and mixtures thereof.

11. The erosion resistant coating of Claim 2, wherein the film is selected from the group consisting of oxides, borides, nitrides, carbides, phosphides, and mixtures thereof.

12. The erosion resistant coating of Claim 1, further comprising nanoparticles dispersed in the metal matrix.

13. The erosion resistant coating of Claim 1, wherein the hard particles are selected from the group consisting of diamond, SiC, B_4C, TiN, TiB_2, Si_3N_4, Al_2O_3, and cBN.

14. The erosion resistant coating of Claim 1, wherein the erosion resistant coating is a substantially continuous film having an average thickness greater than 25 microns.

15. The erosion resistant coating of Claim 1, wherein the plurality of hard particles has a Mohs hardness greater than 7.

16. A hydroelectric turbine component having the coating of Claim 1.

17. A hydroelectric turbine component exposed to silt particles during operation thereof, the hydroelectric turbine component comprising:

an erosion resistant coating comprising a metal matrix; and a plurality of hard particles embedded in the metal matrix, wherein the plurality of hard particles are spaced apart at an average distance equal to or less than 10 microns.

18. The hydroelectric turbine component of Claim 17, wherein the hard particles have a film of a material different from the metal matrix on a surface of each one of the hard particles.

19. The hydroelectric turbine component of Claim 17, wherein the plurality of hard particles have an average diameter of about 0.25 microns to about 12 microns.

20. The hydroelectric turbine component of Claim 17, wherein the metal matrix is selected from a group consisting of cobalt based alloy, a nickel based alloy, and an iron based alloy.

21. The hydroelectric turbine component of Claim 17, further comprising an additive dispersed in the erosion resistant coating, wherein the additive is selected from the group consisting of oxides, borides, nitrides, carbides, phosphides, and mixtures thereof.

22. The hydroelectric turbine component of Claim 17, further comprising nanoparticles dispersed in the metal matrix.

23. The hydroelectric turbine component of Claim 17, wherein the hard particles of diamond, SiC, B_4C, TiN, TiB_2, Si_3N_4, Al_2O_3, or CBN.

24. The hydroelectric turbine component of Claim 17, wherein erosion resistant coating forms a substantially continuous film on the component at an average thickness greater than 25 microns.

25. The hydroelectric turbine component of Claim 17, wherein the hard particles have a Mohs hardness greater than 7.

26. An electroless plating process for forming a hard particle coating onto a hydroelectric turbine component, comprising:

dispersing hard particles in a solution;

forming a metal ion bath comprising a metal sulfate solution, a hypophosphite solution, and deionized water;

heating the bath to a temperature of about 80°C to about 95°C;

submerging and rotating the hydroelectric turbine component in the bath to plate the hydroelectric turbine component with a coating of the hard particles in a metal matrix;

removing the hydroelectric turbine component from the bath; and

heating the hydroelectric turbine component in a furnace to a temperature of about 300°C to about 500°C, wherein the coating has a Mohs hardness greater than 7.

27. The electroless plating process of Claim 26, wherein the hard particles are spaced apart at an average distance equal to or less than 10 microns.

28. The electroless plating process of Claim 26, wherein the metal ion bath has a concentration of metal ions of about 5.5 to about 6.3 grams per liter of bath solution.

29. The electroless plating process of Claim 26, further comprising periodically replenishing the bath so as to maintain the metal ion concentration at about 5.5 to about 6.3 grams per liter.

30. The electroless plating process of Claim 26, further comprising adding soluble additives containing phosphorous or boron to the metal ion bath.

31. The electroless plating process of Claim 26, further comprising forming nanoparticles in the hard particle coating, wherein the nanoparticles comprise carbides, borides, nitrides, or oxides with at least one metal selected from a group of metals consisting of Al, Si, W, Cr, Ti, Nb, Zr, Hf, Ta , and Mo.

32 The electroless plating process of Claim 26, wherein the hard particle coating has a volume fraction of hard particles greater than 25 percent.

33. The electroless plating process of Claim 26, wherein the hard particles have a nominal diameter of 0.25 microns to 12 microns and are spaced apart in the hard particle coating at a distance equal to or less than about 10 microns.

34. The electroless plating process of Claim 26, wherein the coating has an average thickness greater than 25 microns.

35. An electroplating process for forming a hard particle composite coating onto a hydroelectric turbine component, comprising:

forming a metal ion bath comprising a metal sulfate solution and deionized water;

dispersing hard particles in the metal ion bath;

submerging and rotating the hydroelectric turbine component in the bath to plate the hydroelectric turbine component;

fixturing the component as the cathode;

passing current through the bath and the component to form the hard particle coating; and

removing the hydroelectric turbine component from the bath..

36. The process according to Claim 35, wherein the hard particles are spaced apart at an average distance equal to or less than 10 microns.

37. The electroplating process of Claim 35, wherein the metal ion bath has a concentration of metal ions of about 5.5 to about 6.3 grams per liter of bath solution.

38. The electroplating process of Claim 35, further comprising periodically replenishing the bath so as to maintain the metal ion concentration at about 5.5 to about 6.3 grams per liter of bath solution.

39. The electroplating process of Claim 35, further comprising adding soluble additives that contain phosphorous or boron to the metal ion bath.

40. The electroplating process of Claim 35, further comprising forming nanoparticles in the hard particle coating, wherein the nanoparticles comprise carbides, borides, nitrides, or oxides with at least one metal selected from a group of metals consisting of Al, Si, W, Cr, Ti, Nb, Zr, Hf, Ta , and Mo.

41. The electroplating process of Claim 35, wherein the hard particle coating has a volume fraction of hard particles greater than 25 percent.

42. The electroplating process of Claim 35, wherein the hard particles have a nominal diameter of 0.25 microns to 12 microns and are spaced apart in the composite hard particle coating at a distance less than 10 microns.

43. The electroplating process of Claim 35, wherein the substantially continuous film has an average thickness greater than 25 microns.

44. The electroplating process of Claim 35, wherein the hard particles have a Mohs hardness of greater than 7.

45. A process for forming a hard particle coating onto a hydroturbine component, comprising:

submerging the hydroelectric turbine component into an aqueous plating bath at a temperature of about 80°C to about 95°C and for a period of time effective to form a hard particle coating on the hydroelectric turbine component, wherein the plating bath comprises hard particles suspended therein;

removing the hydroelectric turbine component from the bath; and

heating the hydroelectric turbine component in a furnace to a temperature of about 300°C to about 500°C.

46. The process of Claim 45, wherein the aqueous plating bath comprises a nickel salt, a cobalt salt, an iron salt, or combinations comprising at least one of the foregoing salts.

47. The process of Claim 45, further comprising adding soluble additives that contain phosphorous or boron to the aqueous plating bath.

48. The process of Claim 45, further comprising forming nanoparticles in the hard particle coating, wherein the nanoparticles comprise carbides, borides, nitrides, or oxides with at least one metal selected from a group of metals consisting of Al, Si, W, Cr, Ti, Nb, Zr, Hf, Ta , and Mo.

49. The process of Claim 45, wherein the hard particle coating has a volume fraction of hard particles greater than 25 percent based on the total volume of the coating.

50. The process of Claim 45, wherein the hard particles have a nominal diameter of 0.25 microns to 12 microns and are spaced apart in the hard particle coating at an average distance less than or equal to 10 microns.

51. The process of Claim 45, wherein the coating has an average thickness greater than 25 microns.

52. The process of Claim 45, wherein the hard particles have a Mohs hardness greater than 7.

53. A process for reducing erosion, comprising

forming an erosion resistant coating on a surface exposed to silt, wherein the erosion resistant coating comprises a metal matrix, and a plurality of hard particles embedded in the metal matrix, wherein the plurality of hard particles are spaced apart at an average distance less than an average diameter of an impacting silt particle.